DECLARATION

I, Shuichi Tomita, a professional translator, declare that to the best of my knowledge and belief the following English translation is an accurate translation of the certified copy of Japanese Patent Application No. 11-079824 filed in the Japanese Patent Office on March 24, 1999.

Signed, March 10, 2003

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[Title of the Invention] Developing Apparatus

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[Name of Document] Specification 1

[Name of Document] Drawing 1

[Name of Document] Abstract 1

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[Name of Document] SPECIFICATION

[Title of the Invention] Developing Apparatus

[CLAIMS]

[Claim 1]

A developing apparatus comprising a developer carrier for carrying a developer in a developing area opposing a latent image carrier for transportation, and thin layer forming means for forming the developer carried on said developer carrier into a uniform thin film, said developing apparatus adapted to perform a binary development in accordance with a threshold for a potential on said latent image carrier, characterized by employing a one-component developer as a developer, and setting developing conditions such that most of the toner on said developing roller passing the developing area is used for the binary development of a toner adhesion scheduled area of a latent image formed on said photosensitive drum when the toner adhesion scheduled area is passing the developing area under a saturation development characteristic in which the amount of the toner adhered on said photosensitive drum saturates.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Technical Field Pertinent to the Invention]

The present invention relates to a developing apparatus for use in an image forming apparatus such as a copier, a facsimile, a printer and the like.

[0002]

[Prior Art]

Most of electronic data used in recent data processing is digital data, and a digital-based image forming apparatus has also been required for forming images based on digital image data, rather than analog image data. In the image formation using digital image data, the size of a pixel and the like are not continuous but discrete (in steps) due to the nature of the data. Particularly, each pixel is preferably controlled in two steps, i.e., each pixel is controlled in two values in terms of the presence or absence of a dot having a constant image density and size, from a view point of the size of image data, immunity to noise, and the like.

[0003]

[Problem to be solved by the Invention]

However, in an image forming apparatus which controls each pixel in two values, as to the presence or absence of a dot as mentioned above, a developing apparatus for use therein is prone, depending on its developing characteristics, to a failure in adhering a toner at a predetermined density in a toner adhesion scheduled area on a photosensitive drum as a latent image carrier, and to scumming caused by unwanted toner particles adhered around the toner adhesion scheduled area. In addition, stable formation of the dots may be difficult due to a change in the developing characteristics of the developing apparatus possibly caused by environmental conditions at a location at which the apparatus is installed, and to an aging change in the developing

characteristics.

[0004]

The present invention has been made in view of the foregoing problem, and its object is to provide a developing apparatus which is capable of creating stable image densities over time irrespective of environmental conditions without causing scumming.

[0005]

[Means Taken for Solving the Problems]

To achieve the above object, the present invention provides a developing apparatus which comprises a developer carrier for carrying a developer in a developing area opposing a latent image carrier for transportation, and thin layer forming means for forming the developer carried on the developer carrier into a uniform thin film, to perform a binary development in accordance with a threshold for a potential on the latent image carrier, characterized by employing a one-component developer as a developer, and setting developing conditions such that most of the toner on the developing roller passing the developing area is used for the binary development of a toner adhesion scheduled area of a latent image formed on the photosensitive drum when the toner adhesion scheduled area is passing the developing area under a saturation development characteristic in which the amount of the toner adhered on the photosensitive drum saturates.

[0006]

In the developing apparatus according to the present invention, the developer can be stably adhered on the latent image carrier without scumming by performing the binary development under the saturation development characteristic in which the amount of adhered developer fluctuates in a smaller magnitude, even with fluctuations in the developing conditions such as the potential on the surface of the latent image carrier, and fluctuations in the developer characteristics such as the amount of charged developer and the like due to alternations in the environmental conditions and aging changes. In addition, since most of the developer on the developer carrier passing the developing area, when a developer adhesion scheduled area of a latent image formed on the latent image carrier is passing the developing area, is used for the binary development of the developer adhesion scheduled area, the developer can be adhered on the latent image carrier at a predetermined density. Furthermore, since a one-component developer is used as the developer, most of the developer carried on the developer carrier can be more securely transferred to the latent image carrier for use in the development of the latent ~~image on the~~ latent image carrier.

[0007]

[Embodiments]

In the following, description will be made on one embodiment in which the present invention is applied to a developing apparatus for an electrophotographic copier as an image forming

apparatus which performs a binary imagery process development. Fig. 2 is a general cross-sectional view of the developing apparatus for the copier which performs the binary imagery process development. This developing apparatus comprises a developing roller 3 as a developer carrier which carries and transports a toner 2 as a single-component developer to a developing area 1 opposing a photosensitive drum 1 as a latent image carrier; a doctor blade 4 as a thin layer forming member for forming the toner 2 carried by the developing roller 3 into a uniform thin layer; a toner supply roller 5 as a developer supplying member for supplying the toner 2 to the developing roller 3; a toner container 6 as a developer storage case for storing the toner 2 supplied from the toner supply roller 5; and an agitator 7 for agitating and feeding the toner 2 stored in the toner container 6 to the toner supply roller 5.

[0008]

The toner 2 used in the developing apparatus may be a non-magnetic toner which has a grain diameter in a range of 5 to 7.5 [μm], and made of a resin material such as polyol, polyester, styrene acrylic added with a charging control agent (CCA) such as acetyl acid and an external additive such as silica, titanium oxide or the like.

[0009]

As illustrated in Fig. 2, the developing roller 3 opposes the surface of the photosensitive drum 1 in a developing area A across a predetermined developing gap Gp for performing a

contact or non-contact development. The size of the developing gap Gp is preferably 150 [μm] or less. As shown in the result of an experiment in Fig. 3, the developing gap Gp larger than 150 [μm] causes a dot width to fall below 20 [pixel] at a developing potential of 150 [V], resulting in a thin dot and a consequent degradation in the image quality. The result of the experiment in Fig. 3 was obtained by applying the developing roller 3 with a developing bias voltage which is generated by multiplexing an AC voltage (rectangular wave) having a peak-to-peak voltage Vp-p equal to 1200 [V] and a frequency F equal to 2 kHz on a DC voltage, where "Vp" in Fig. 3 represents the value of the developing potential.

[0010]

The developing apparatus is configured to keep a discoidal spacer roller (not shown) formed to have a radius larger by the desired developing gap Gp than the radius of the developing roller 3 in contact with the surface of the photosensitive drum 1 other than a latent image forming area.

[0011]

Also, the developing roller 3 is preferably subjected to blasting which involves colliding uniform metal or glass grains with aluminum or the like at a high speed. The developing roller 3 preferably has a surface roughness of 1 to 4 [μm] in RZ. This surface roughness is 13 to 80 % of the toner grain diameter, permitting the toner to be transported without being sunk into the surface of the developing roller 3. Also, the surface of

the developing roller 3 may be covered with a resin for stabilizing the quality over time. The material for the resin is preferably based on silicon or Teflon (registered trademark). The former material results in a well charged toner, while the latter excels in mold release characteristics. In addition, a coating means may be changed to permit a good development even if a metal base made of aluminum is partially exposed.

[0012]

The developing roller 3 is also applied with a development bias voltage by a bias source (not shown) which provides a good flight condition for the toner. The development bias voltage used herein is generated by multiplexing an AC voltage on a DC voltage. This AC voltage preferably has the value of a peak-to-peak voltage Vp-p in a range of 600 to 1200 [V]. As shown in Fig. 4, the value of the peak-to-peak voltage Vp-p of the AC voltage below 600 [V] causes a reduction in a dot area of an apparent image on the developing roller 3, resulting in a degraded image quality. On the other hand, the value of the peak-to-peak voltage Vp-p of the AC voltage above 1200 [V] causes a discharge in the air in accordance with the Paschen's law, failing to apply the development bias voltage to significantly degrade the image quality.

[0013]

The doctor blade 4 is in contact with developing roller 3 at its trailing end. The material for the doctor blade 4 may be a metal such as SUS304 having a thickness of 0.1 to 0.15

[mm]. Other than this material, the doctor blade 4 can be made of a rubber material such as polyurethane rubber having a thickness of 1 to 2 [mm], or a resin material such as silicon resin. The doctor blade 4 preferably has a free end length of 10 to 15 [mm] from a blade holder. The length exceeding the upper limit would result in a cumbersome developing apparatus which cannot be housed in compact. On the other hand, the length falling below the lower limit would prevent vibrations when the doctor blade 4 rubs with the surface of the developing roller 4, causing a horizontal gradation in a resulting solid image. The doctor blade 4 is preferably in contact with the developing roller 3 at a pressure in a range of 10 to 150 [g/cm]. The pressure exceeding the upper limit would cause a reduction in the amount of the toner adhered on the developing roller 3 and an excessive amount of the charged toner, resulting in a reduced developing amount and a lower image density. On the other hand, the pressure falling below the lower limit would fail to uniformly form the thin film on the developing roller 3 and cause a bulk of toner to pass through the blade, thereby significantly degrading the image quality.

[0014]

The toner supply roller 5 has an elastic foam layer deposited on the surface ~~thereof, and~~ is formed with a large number of voids extending through the surface such that the toner can be held inside of at least the vicinity of the surface of the elastic foam layer.

[0015]

The agitator 7 supplies the toner 2 in the developer container 3 to the surface of the toner supply roller 5 and agitates the toner 2, but may be omitted if the toner can be supplied to the surface of the toner supply roller 5 by the action of the self weight of the toner possibly resulting from the shape of the developer container 3, the flowability of the toner, and the like.

[0016]

In the foregoing configuration, the toner 2 in the developer container 3 is supplied by the agitator 7 to the surface of the toner supply roller 5. The toner 2 supplied to the toner supply roller 5 is carried to a point at which the toner supply roller 5 comes into contact with the developing roller 3 by the counter-clockwise rotation of the toner supply roller 5. At the contact, the toner is charged by friction of the toner supply roller 5, toner and the developing roller 3, and is supplied to the surface of the developing roller 3. The toner supplied to the surface of the developing roller 3 is formed into a thin layer and frictionally charged by the doctor 3 which serves as a layer thickness limiting plate, so that the toner adheres on the surface of the developing roller 3 in a desired charging amount and in a desired thickness, and carried to the developing area A opposite to the photosensitive drum 3 by the rotation of the developing roller 3.

[0017]

In the developing area A, the toner on the surface of the developing roller 3 applied with a bias voltage for forming an appropriate electric field reciprocates between the developing roller 3 and photosensitive drum 1 to actualize an electrostatic latent image formed on the surface of the photosensitive drum 1. Here, the reciprocal movements of the toner mean that the toner reciprocates both between an image area and an non-image area on the developing roller 3 and photosensitive drum 1, but strictly, also include the toner which does reciprocate between the non-image area and photosensitive drum 1 but transfers from the developing roller 3 to the image area without returning therefrom, in other words, the toner which only moves to the photosensitive drum 1 during the passage through the developing area A. A residual toner, which does not adhere on the surface of the photosensitive drum 1 when it passes the developing area A and remains on the surface of the developing roller 3 is mechanically and electrically scraped off from the developing roller 3 by the toner supply roller 5. Also, the charge on the developing roller 3 is made uniform by the frictional charging of the toner supply roller 5 to initialize the surface of the developing roller 3.

[0010]

In this type of developing apparatus which involves the binary imagery process development, a change in the developing potential would result in varying dot areas of an apparent image on the photosensitive drum at 600 [dpi] with populated dots

that provide only two empty dots for one written dot, as mentioned above.

[0019]

The developing apparatus according to this embodiment, thus, sets developing conditions such that the binary development is performed under a saturation development characteristic in which the amount of the toner adhered on the photosensitive drum saturates in accordance with an increase in the developing potential. In this developing apparatus, the amount of the toner adhered on the photosensitive drum 1 equal to 0.7 [mg/cm^2] causes the density of an image to increase to 1.5 times as high as a target value from the relationship of the degree of pigmentation of the toner. Fig. 1 is a graph showing the relationship between the developing potential and the amount of the toner adhered on the photosensitive drum 1 in this developing apparatus. In the graph, data indicated by symbols "□" and "△" represent experiment data which are taken when the amount m/a of the toner on the developing roller 3 is 0.5 [mg/cm^2] and 1.6 [mg/cm^2], respectively. The data indicated by symbol "□" represents the saturation development characteristic which exhibits a saturated amount of the toner adhered on the photosensitive drum 1 with an increase in the developing potential, where the thickness of the toner layered on the developing roller 3 is assumed to be 1 - 1.5 layers as converted to the number of toners. This results in an ideal binary development which provides a predetermined image density

without scumming. Contrary to the foregoing, the data indicated by the symbol "△", given as a comparative example, shows that the thickness of the toner layered on the photosensitive drum 1 increases to 3 - 4 layers as converted to the number of toners, so that all layers cannot be developed with a defined developing potential. Since the developing amount increases as the developing potential is increased, the developing amount is changed by fluctuations in the potential on the photosensitive drum 1 caused by fluctuations in an optical writing system, resulting in an instable image density.

[0020]

Fig. 5 shows the development gamma (γ) characteristic when the toner is charged in different amounts. Data indicated by symbols "◇" and "□" in the graph are measured for a highly charged toner with a charging amount g/m equal to -13 [μC/g] and for a lowly charged toner with the charging amount g/m equal to -10 [μC/g], respectively. The result in Fig. 5 shows that the amount of adhered toner saturates at the developing potential on the order of 100 [V] when a toner charging amount is smaller than -10 [μC/g] in absolute value, while the amount of adhered toner increases until the developing potential reaches about 300 [V] when the toner charging amount is larger than -10 [μC/g] in absolute value. In this way, as the toner charging amount increases, the developing amount changes, affected by fluctuations in the potential on the photosensitive drum 1, resulting in a varying image density.

[0021]

[Effects of the Invention]

The present invention can highly advantageously provide stable image densities over time irrespective of environmental conditions without scumming, by developing a developer adhesion scheduled area of a latent image formed on a latent image carrier in binary, using a single-component developer under the saturation development characteristic.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1]

A graph showing the development gamma characteristics when using a parameter which is the amount of toner adhered on a developing roller in a developing apparatus according to the present invention.

[Fig. 2]

A diagram generally illustrating the configuration of the developing apparatus.

[Fig. 3]

A graph showing the relationship between a developing gap and a dot width when using a parameter which is the developing potential in the developing apparatus.

[Fig. 4]

A graph showing the relationship between the developing potential and dot area when using a parameter which is a peak-to-peak voltage value of a developing bias voltage in the developing apparatus.

[Fig. 5]

A graph showing the development gamma characteristics when using a parameter which is the amount of charged toner in the developing apparatus.

[Description of Reference Numerals]

1 Photosensitive Drum

2 Toner

3 Developing Roller

4 Doctor Blade

5 Toner Supply Roller

6 Toner Container

7 Agitator

[Name of Document] ABSTRACT

[ABSTRACT]

[PROBLEM]

A developing apparatus is provided for creating stable image densities over time irrespective of environmental conditions without scumming.

[SOLUTION]

A one component developer is used as a developer. Developing conditions such as the amount of toner adhered on a developing toner 2 are set such that most of the toner on the developing roller 3 passing a developing area is used for a binary development of a toner adhesion scheduled area of a latent image formed on a photosensitive drum 1 when the toner adhesion scheduled area is passing the developing area under a saturation development characteristic in which the amount of the toner adhered on the photosensitive drum 1 saturates.

[SELECTED DRAWING] FIG. 1